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E7.4-10.188
CR-136327

# Detection of Moisture and Moisture Related Phenomena from Skylab

(E74-10188) DETECTION OF MOISTURE AND MOISTURE RELATED PHENOMENA FROM SKYLAB Monthly Progress Report, Dec. 1973 (Kansas Univ. Center for Research, Inc.) 19 p HC $3.00 CSCL 08M G3/13

N74-14052

Unclas 00188

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Monthly Progress Report, December 1973

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# Detection of Moisture and Moisture Related Phenomena from Skylab

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EREP NO. 540-A2 March 19, 1973 to August 31, 1974

Contract Number NAS 9-13273

## S194 Measurements and Soil Moisture

Initial correlations between the S194 antenna temperature and soil moisture content have been made for three sets of data. One of these obtained for June 5, 1973 from Skylab 2 was previously reported (October Progress Report). Further analysis of these data and comparisons with that obtained from Skylab 3 on August 5 in Kansas and August 8 in Texas will be included in this progress report.

The test sites for Skylab 3 data collection are shown in Figure 1 for Kansas and 2 for Texas. These figures also show the distribution of weather radar echoes several days prior to Skylab data collection. Although the radar echoes are not always good measures of rainfall at the surface, they do serve as useful supplementary information on moisture distributions. Actual soil moisture measurements were used for correlating with Skylab data.

Correlation coefficients were calculated using the S194 antenna temperature measured every 3.5 nautical miles from Skylab 2 on June 5, 1973 over the Texas test site. Table 1 gives the correlation coefficients and regression equations determined for various soil depths. This table differs slightly from a similar table reported in October since three antenna temperatures were averaged to obtain the previous correlations. Table 1 was obtained by correlating single antennae temperatures measured every 3. 5 nautical miles with the average measured soil moisture within a 3.0 nautical mile radius of the center point of the radiometric measurement. The antenna temperature is highly correlated with the moisture content of the surface layers with the 0 to 2 inch layer slightly better than the 0 to 1 inch layer for the first set of data. Figures 3 and 4 show the relationships for these two layers.

TABLE I:

CORRELATION BETWEEN SOIL MOISTURE AND S-194 ANTENNA TEMPERATURE

SL2: 6-5-73 Texas

| Soil Moisture Layer | Correlation Coefficient | Regression Equation |
|---|---|---|
| 0-1 inch | -0.984 | SM=94.80 - 0.3353AT |
| 1-2 inch | -0.985 | SM=88.02 - 0.2996AT |
| 2-3 inch | -0.938 | SM=65.63 - 0.2097AT |
| 3-4 inch | -0.905 | SM=59.30 - 0.1816AT |
| 4-5 inch | -0.863 | SM=53.69 - 0.1589AT |
| 5-6 inch | -0.857 | SM=61.03 - 0.1873AT |
| 0-2 inch | -0.987 | SM=91.33 - 0.3171AT |
| 0-3 inch | -0.979 | SM=82.83 - 0.2816AT |
| 3-6 inch | -0.977 | SM=58.01 - 0.1760AT |
| 0-6 inch | -0.955 | SM=72.13 - 0.2359AT |

Sample Size=50
SM=Soil Moisture
AT=Antenna Temperature

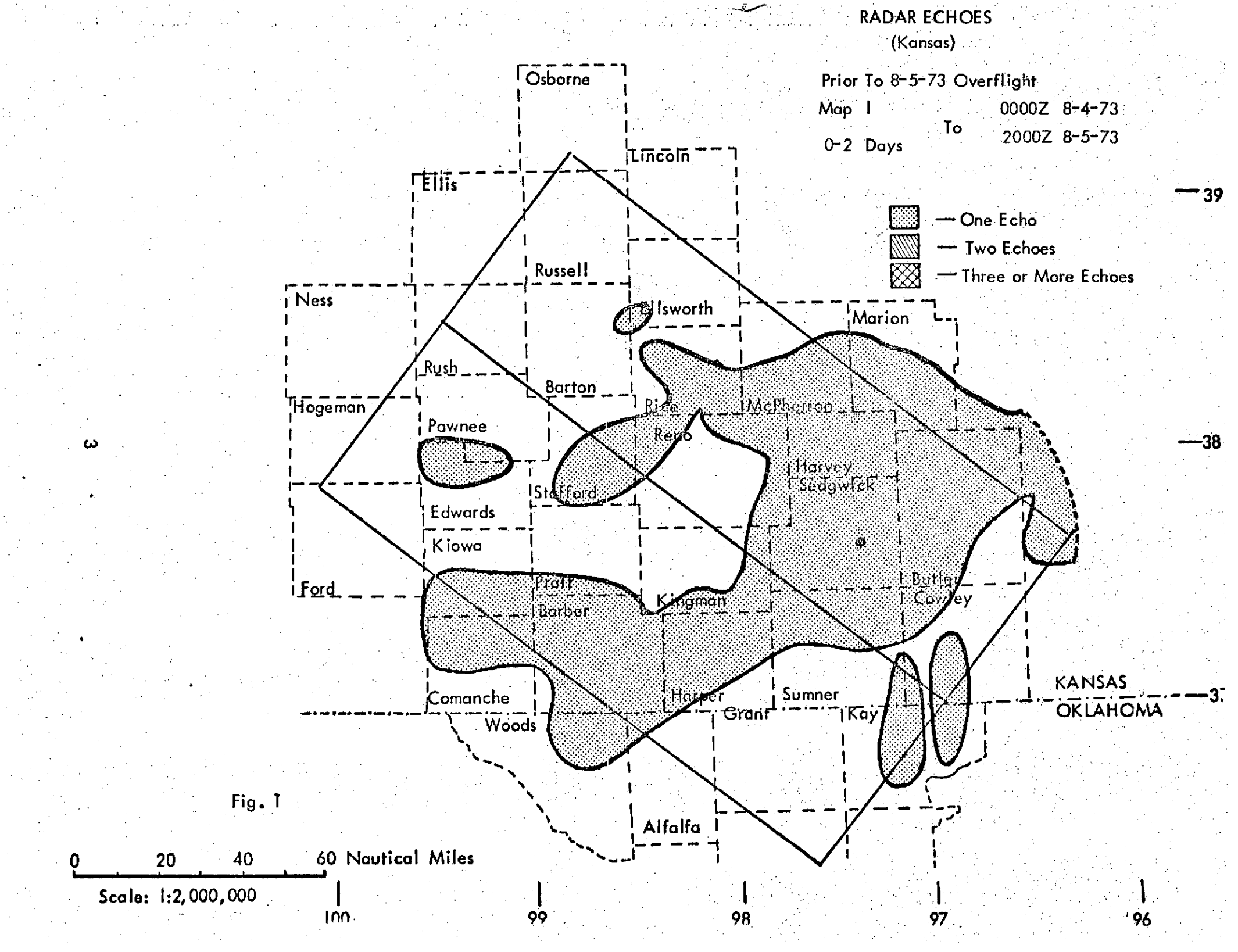
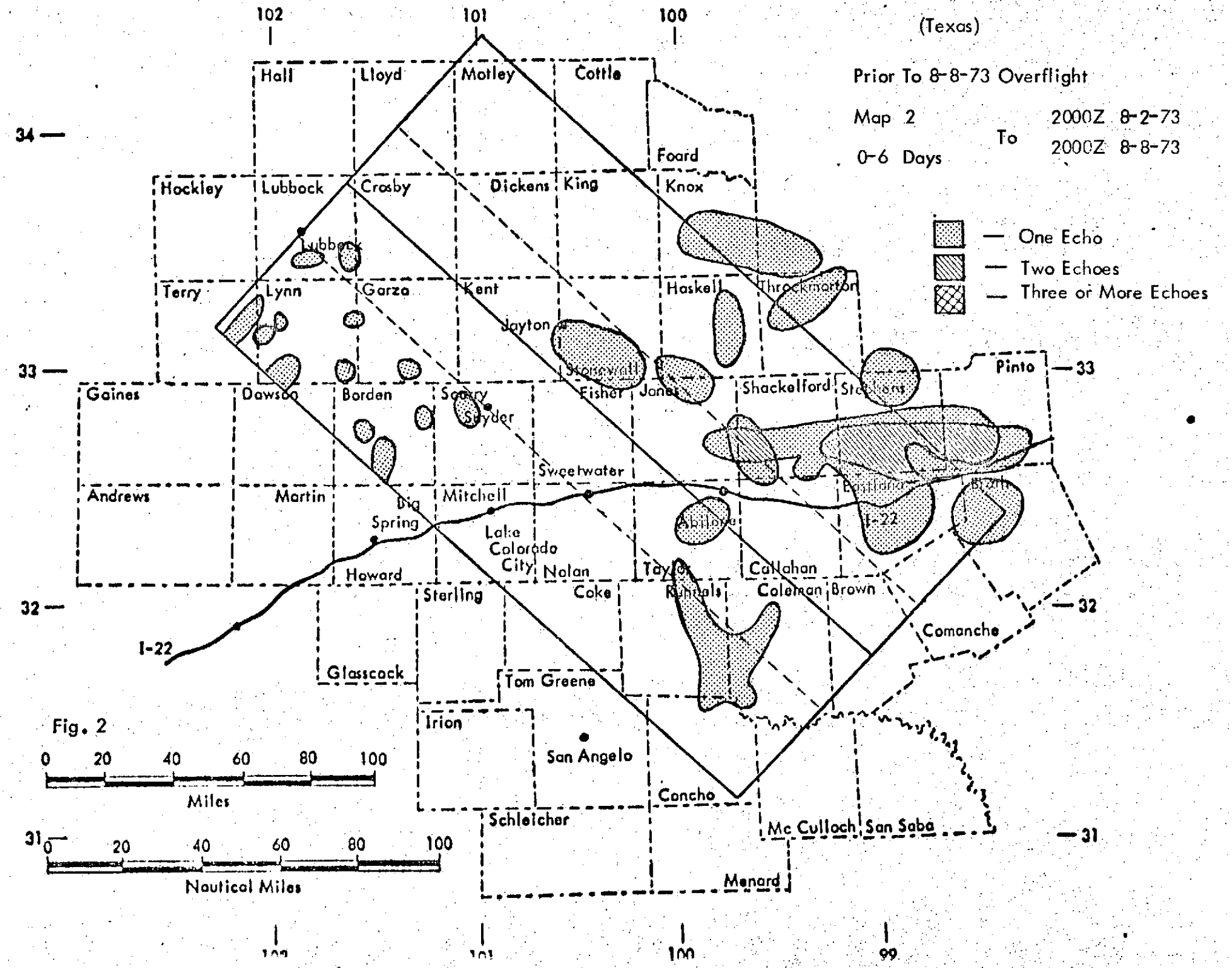

RADAR ECHOES
(Kansas)
Prior To 8-5-73 Overflight
Map 1
0-2 Days
0000Z 8-4-73
To
2000Z 8-5-73
One Echo
Two Echoes
Three or More Echoes
Osborne
Lincoln
Ellis
Russell
Ness
Ellsworth
Marion
Rush
Barton
Hogeman
Rice
McPherson
Pawnee
Reno
Harvey
Sedgwick
Stafford
Edwards
Kiowa
Ford
Pratt
Kingman
Butler
Barber
Cowley
Comanche
Harper
Sumner
KANSAS
OKLAHOMA
Woods
Grant
Kay
Alfalfa
0 20 40 60 Nautical Miles
Scale: 1:2,000,000
100
99
98
97
96
39
38
37

Fig. 1


RADAR ECHOES
(Texas)
Prior To 8-8-73 Overflight
Map 2
0-6 Days
2000Z 8-2-73
To
2000Z 8-8-73
One Echo
Two Echoes
Three or More Echoes
102
101
100
99
34
33
32
31
Hall
Lloyd
Motley
Cottle
Foard
Knox
Hockley
Lubbock
Crosby
Dickens
King
Terry
Lynn
Garza
Kent
Haskell
Throckmorton
Jayton
Stonewall
Fisher
Jones
Shackelford
Stephens
Pinto
Gaines
Dawson
Borden
Scurry
Snyder
Andrews
Martin
Mitchell
Sweetwater
Big Spring
Lake Colorado City
Howard
Sterling
Coke
Nolan
Taylor
Runnels
Callahan
Coleman
Brown
Abilene
I-22
Comanche
Glasscock
Tom Green
Irion
San Angelo
Concho
Schleicher
Mc Culloch
San Saba
Menard
Fig. 2
0 20 40 60 80 100
Miles
0 20 40 60 80 100
Nautical Miles

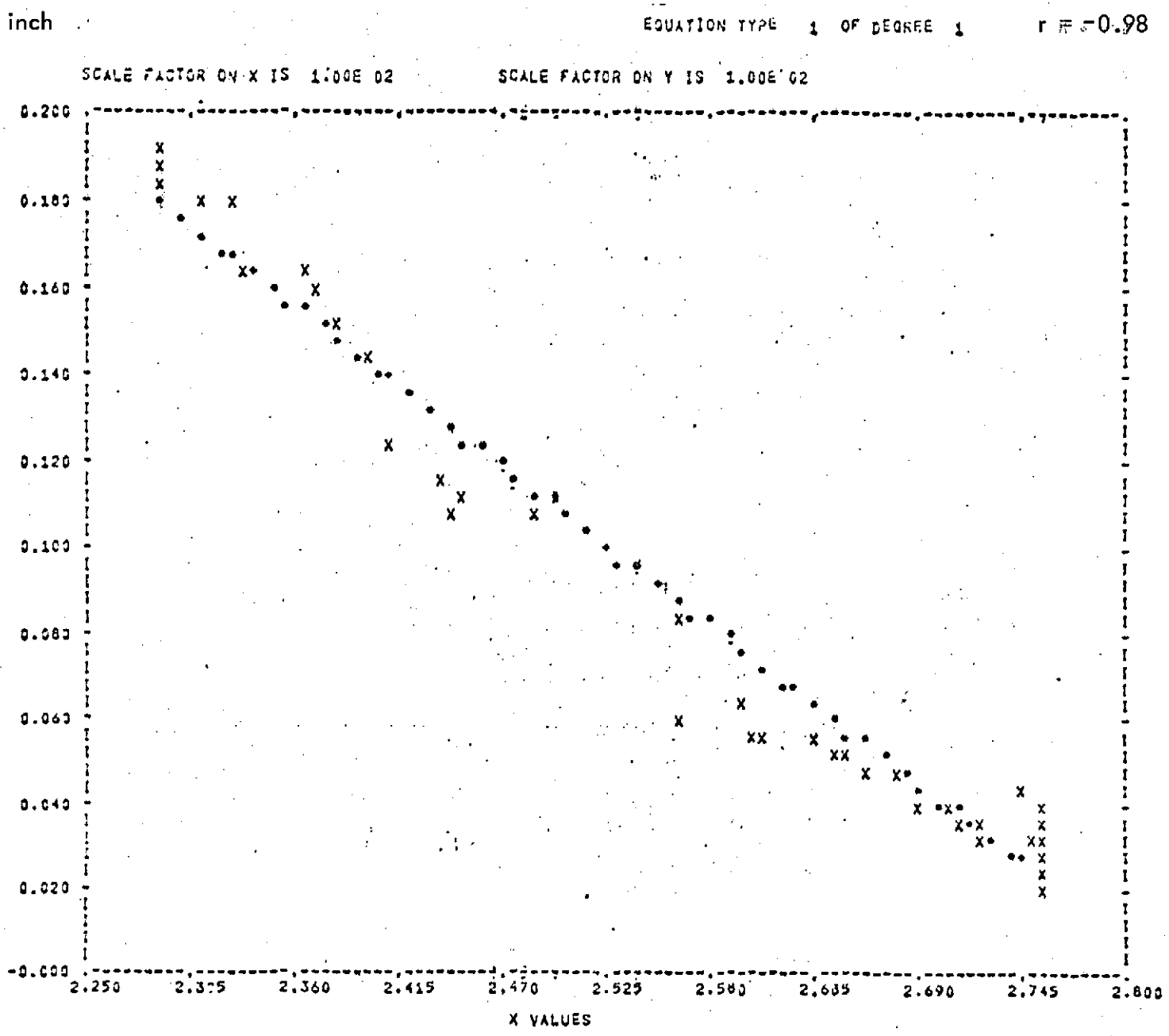



Fig. 3 Correlation Scattergram---Antenna temperature vs. soil moisture 0-1 inch in depth.

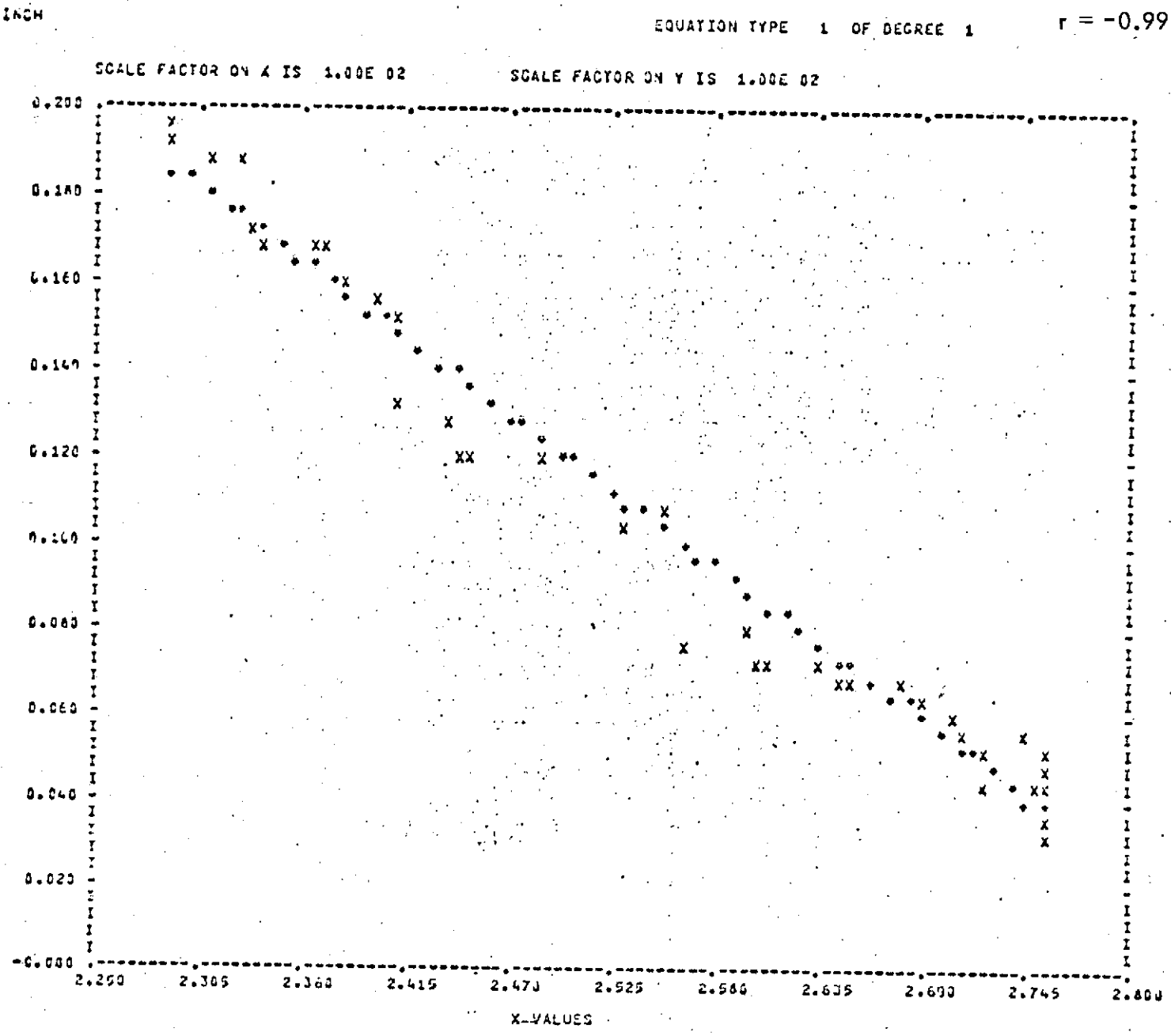



Fig. 4 Correlation Scattergram---Antenna temperature vs. soil moisture 0-2 inches in depth.

A similar analysis of Skylab 3 data obtained on August 5, 1973 over the Kansas site resulted in correlation coefficients and regression equations shown in Table II. The correlation coefficients are not as high for this set of data. The best correlation between the antenna temperature and soil moisture existed for the 0 to 1 in. layer with the 0 to 2 inch layer second. Scatter diagrams of these relationships are shown in Figures 5 and 6. The correlation coefficients may be lower because of the small variations in soil moisture across the test site. Figure 7 shows that the surface moisture varied from slightly more that 1% to a little less than 5%. With this small variation over a distance of 84 nautical miles the location of soil moisture sampling sites and measurement techniques were much more critical than with larger variations and may have contributed to lower correlations. Corresponding antenna temperatures over the test site are shown in Figure 8. The variations were small and are in the same direction as observed previously over the Texas test site.

Data obtained over Texas on August 8 from Skylab 3 again gave good correlations as shown in Table III. The highest correlation between antenna temperature and soil moisture was obtained for the 0 to 1 inch layer (-0.95). Because of the past history of rainfall the soil moisture of the surface layer was not as correlated with the moisture content of deeper layers. The correlation between antenna temperature and soil moisture dropped to -0.81 for the 1 to 2 inch layer of soil. The 0 to 2 inch layer average is also considerable less than that of the 0 to 1 inch layer. The scatter diagrams for these two layers are shown in Figures 9 and 10.

Actual variations in Antenna Temperature and soil moisture are shown in Figures 11 and 12 respectively. Total soil moisture variations were almost 13% with lower antenna temperatures corresponding to higher moisture contents.

## Summary of Significant Results

Correlations between the S194 antenna temperature and soil moisture have been obtained for three sets of data; one for Skylab 2 and two for Skylab 3. The best correlations were obtained for the surface to one inch depth in two cases and for the surface to two inches depth for the third case. Correlation coefficients for the surface to one inch depth were -0.98, -0.95 and -0.82. The lowest correlation coefficient was obtained with total soil moisture variations less than 4% across the test site.

TABLE II

CORRELATION BETWEEN SOIL MOISTURE AND S-194 ANTENNA TEMPERATURE

SL3: 8-5-73 Kansas

| Soil Moisture Layer | Correlation Coefficient | Regression Equation |
|---|---|---|
| 0-1 inch | -0.820 | SM=136.29 - 0.4901AT |
| 1-2 inch | -0.791 | SM=167.96 - 0.5901AT |
| 2-3 inch | -0.790 | SM=153.97 - 0.5319AT |
| 3-4 inch | -0.786 | SM=143.98 - 0.4952AT |
| 4-5 inch | -0.718 | SM=106.02 - 0.3527AT |
| 5-6 inch | -0.806 | SM=140.01 - 0.4779AT |
| 0-2 inch | -0.807 | SM=152.18 - 0.5402AT |
| 0-3 inch | -0.806 | SM=152.62 - 0.5369AT |
| 3-6 inch | -0.777 | SM=129.98 - 0.4418AT |
| 0-6 inch | -0.780 | SM=141.53 - 0.4902AT |

Sample Size=20
SM=Soil Moisture
AT=Antenna Temperature

0 - 1 inch

EQUATION TYPE 1 OF DEGREE 1 r = -0.82

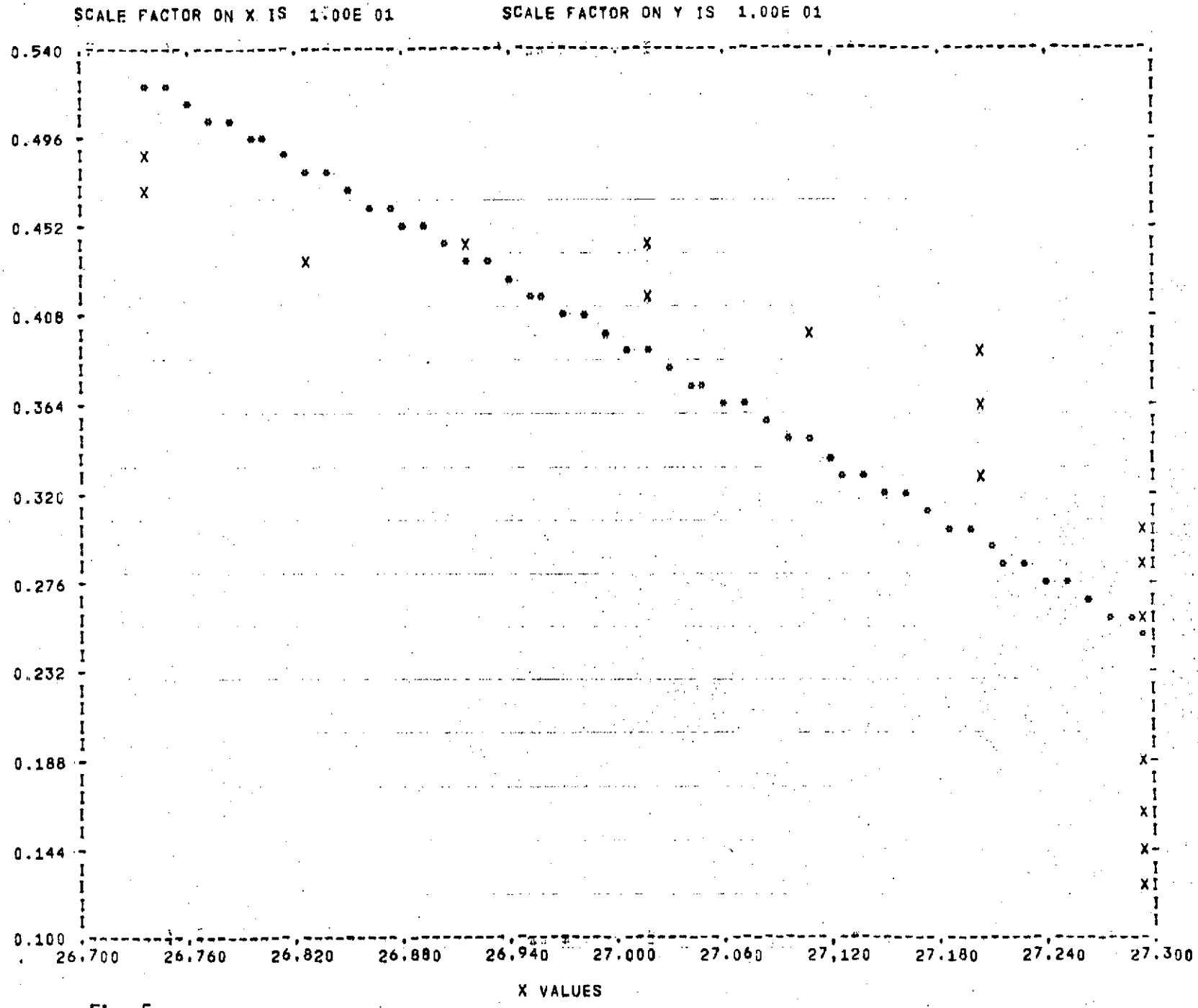



Fig. 5

0 - 2 inch

EQUATION TYPE 1 OF DEGREE 1 $r = -0.81$

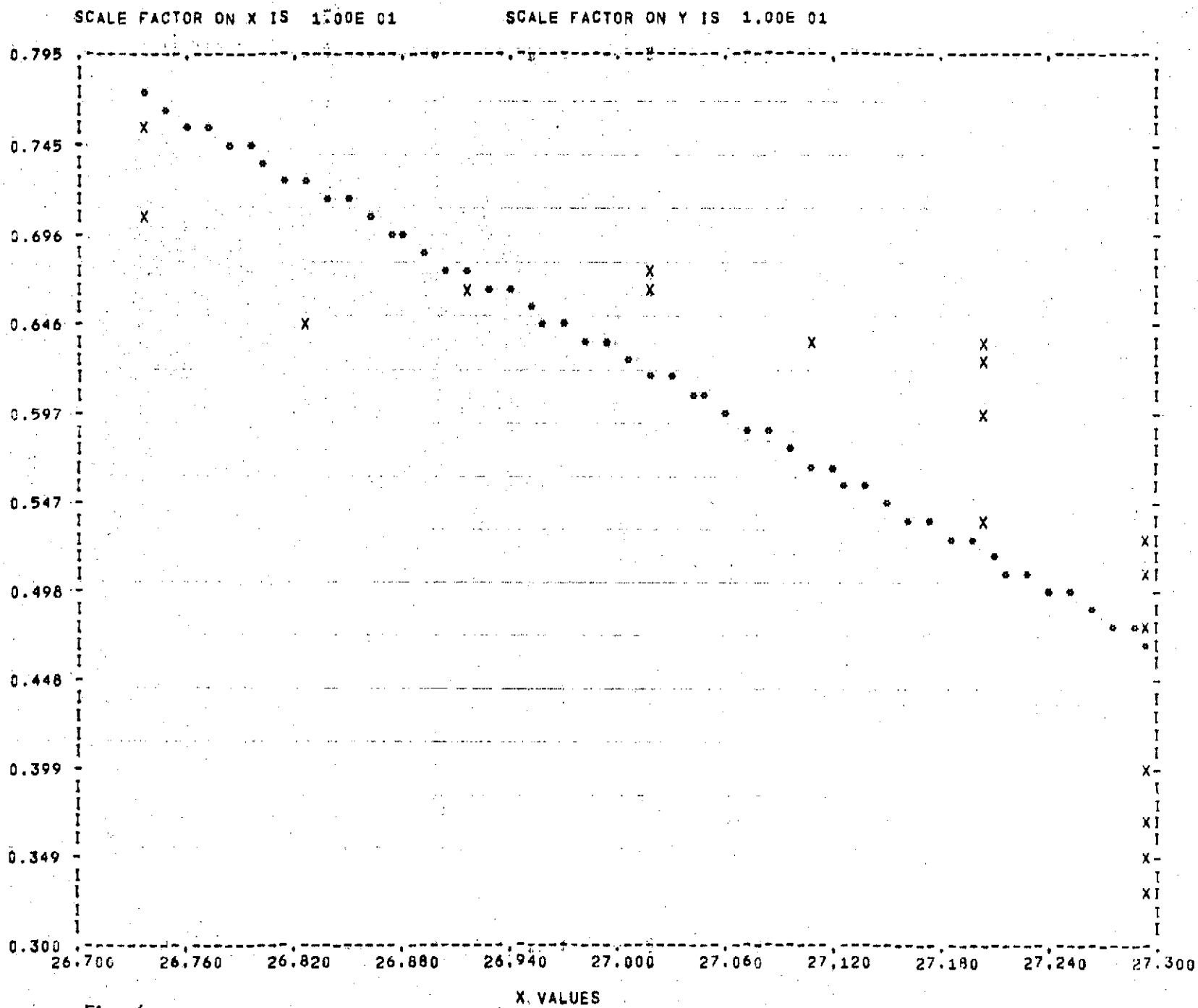
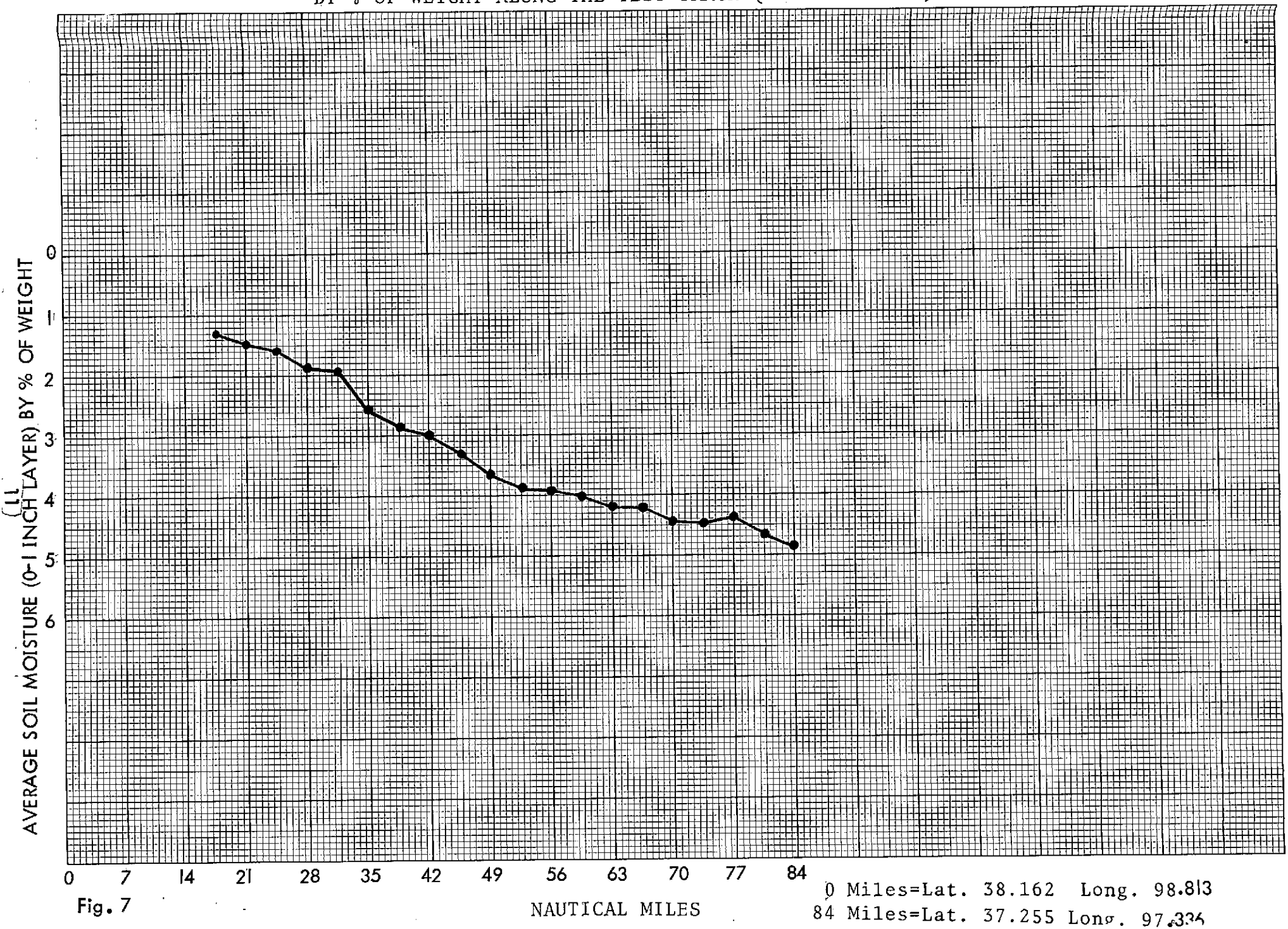



Fig. 6

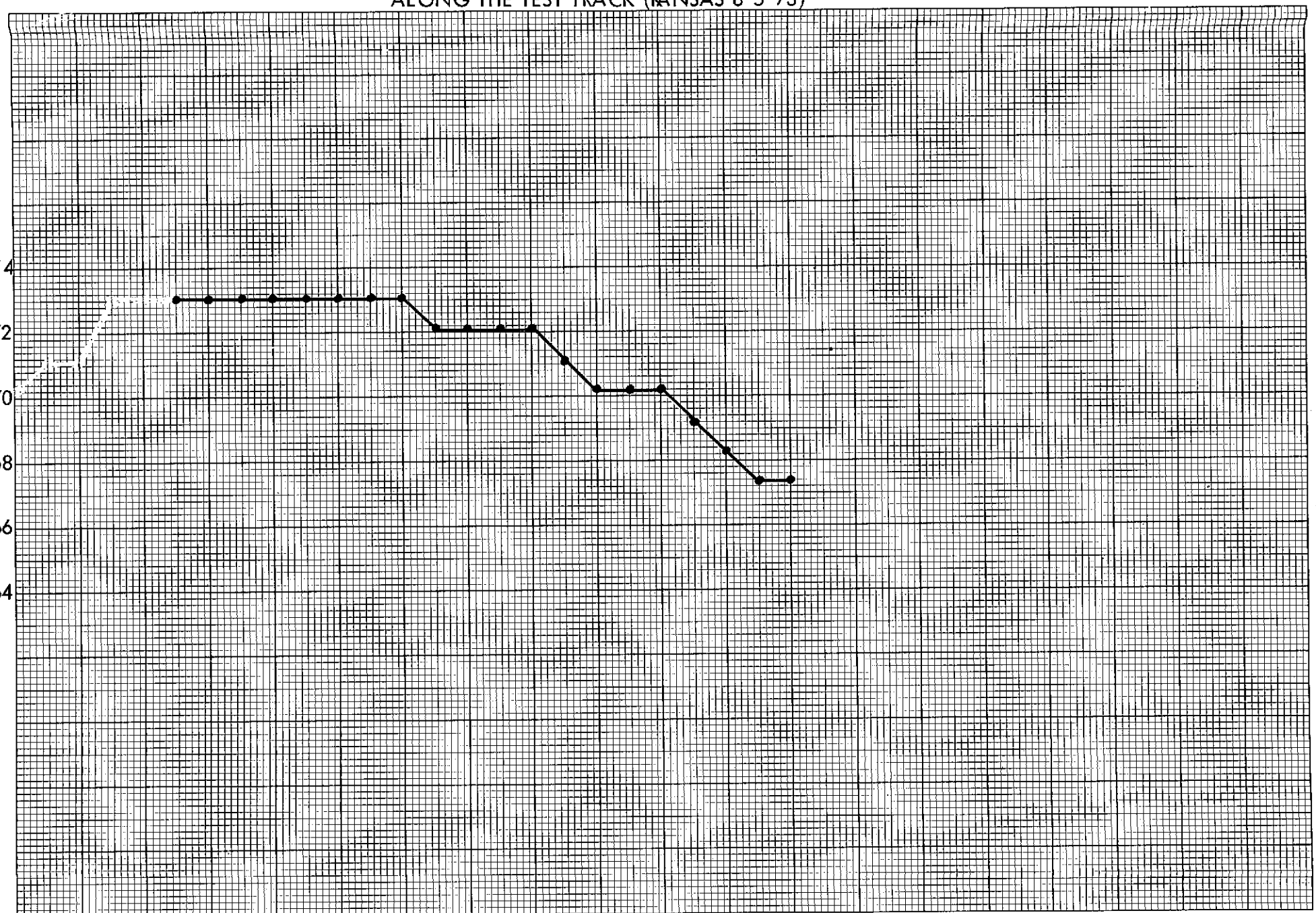
VARIATION OF THE AVERAGE SOIL MOISTURE (0-1 inch layer)
BY % OF WEIGHT ALONG THE TEST TRACK (KANSAS 8-5-73)




0 Miles=Lat. 38.162 Long. 98.813
84 Miles=Lat. 37.255 Long. 97.336

Fig. 7

S-194 TEMPERATURE VARIATIONS IN DEGREES K
ALONG THE TEST TRACK (KANSAS 8-5-73)




0 Miles=Lat. 38.162 Long. 98.813
84 Miles=Lat. 37.255 Long. 97.336

Fig. 8

TABLE III:

CORRELATION BETWEEN SOIL MOISTURE AND S-194 ANTENNA TEMPERATURE

8-8-73 Texas

| Soil Moisture Layer | Correlation Coefficient | Regression Equation |
|---|---|---|
| 0-1 inch | -0.954 | SM=112.43-0.4001AT |
| 1-2 inch | -0.811 | SM= 69.88-0.2359AT |
| 2-3 inch | -0.490 | SM= 39.12-0.1151AT |
| 3-4 inch | -0.034 | SM= 11.44-0.0087AT |
| 4-5 inch | 0.251 | SM= 8.09+0.0670 AT |
| 5-6 inch | 0.388 | SM=-15.97+0.0972AT |
| 0-2 inch | -0.911 | SM= 91.15-0.3180AT |
| 0-3 inch | -0.839 | SM= 73.81-0.2503AT |
| 3-6 inch | 0.205 | SM= -4.18+0.0517AT |
| 0-6 inch | -0.440 | SM= 34.79-0.0992AT |

Sample Size=50
SM=Soil Moisture
AT=Antenna Temperature

0-1 inch

EQUATION TYPE 1 OF DEGREE 1 r = -0.95

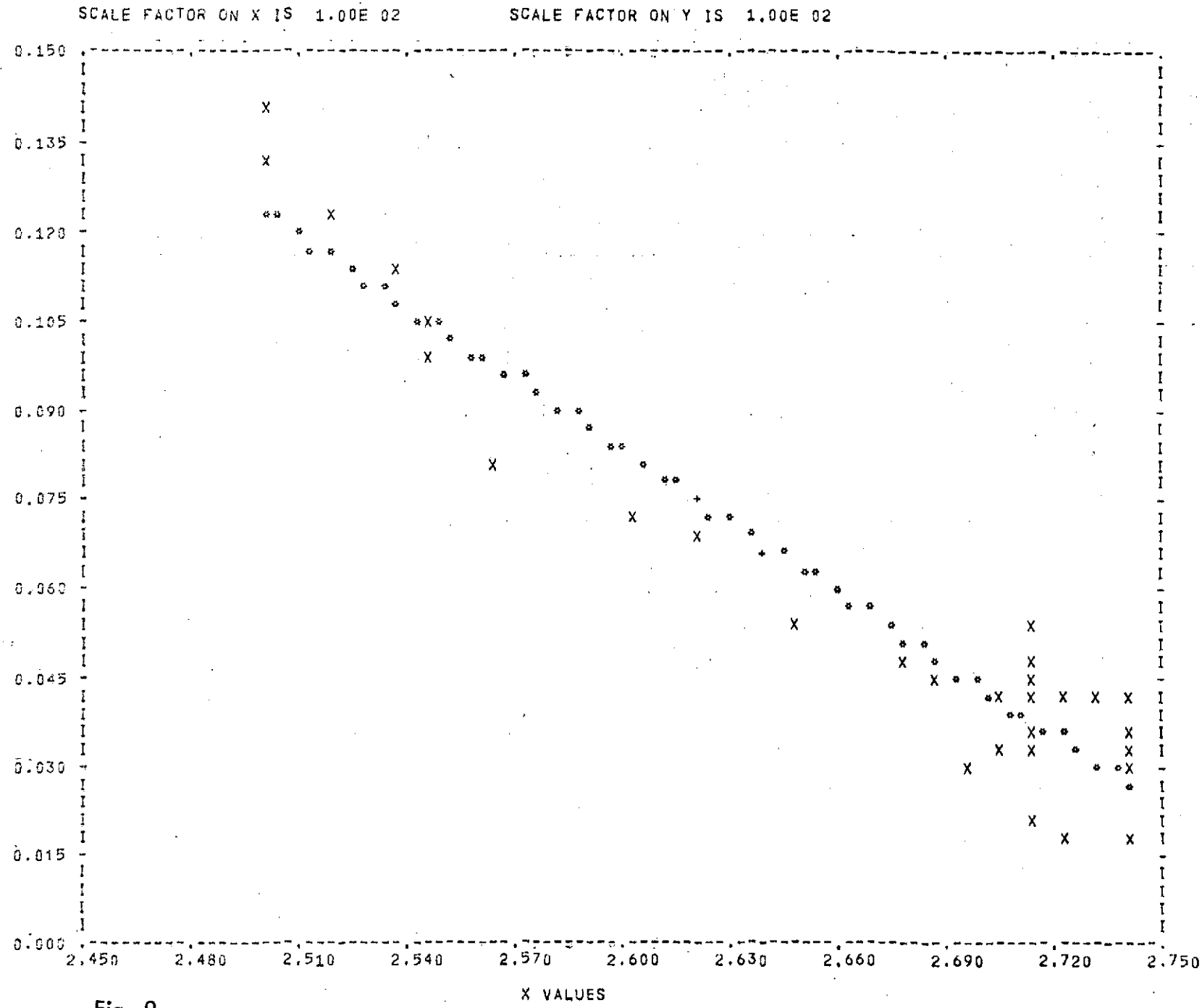



Fig. 9

0-2 INCH

EQUATION TYPE 1 OF DEGREE 1 r = -0.91

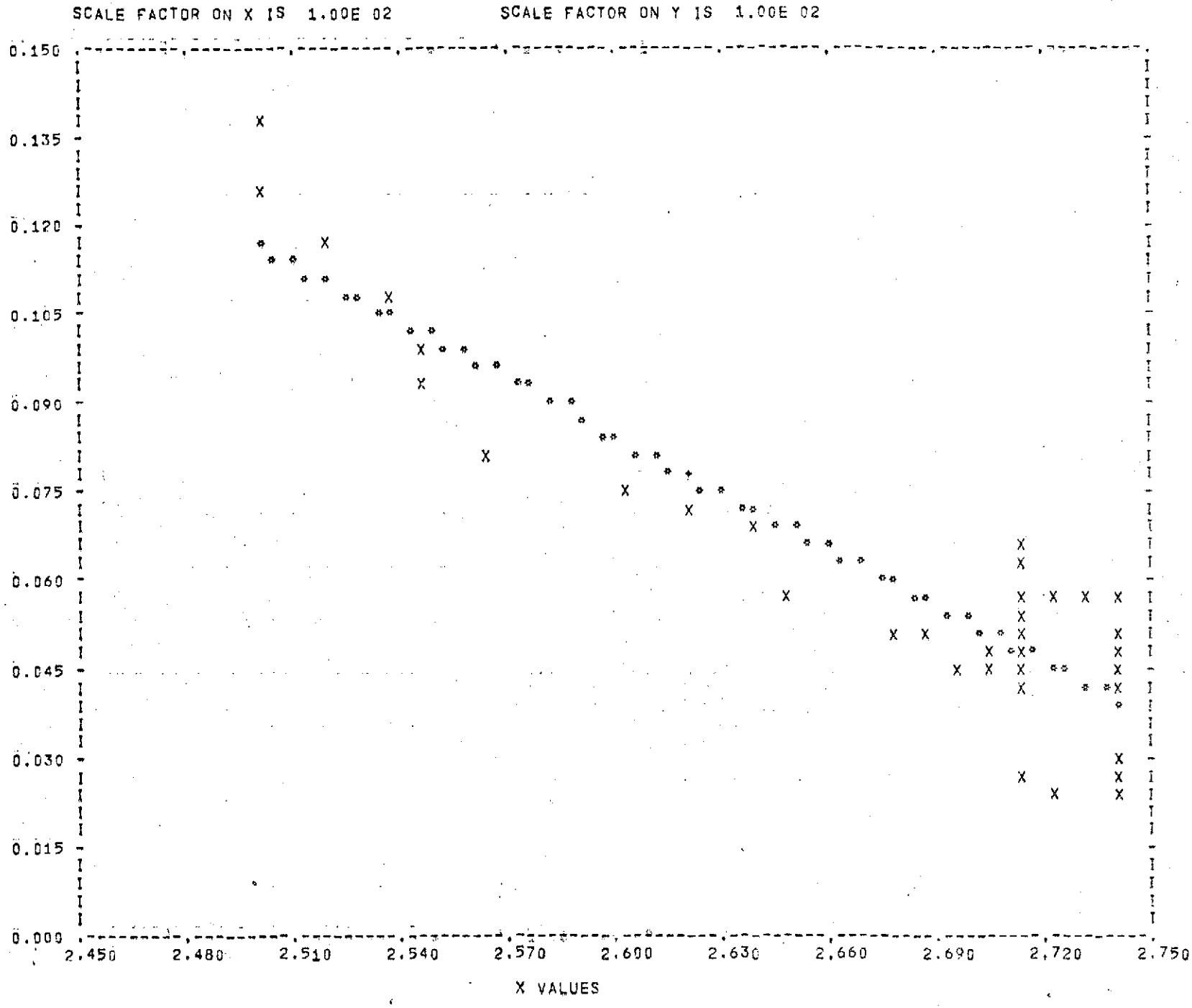





Fig. 10

S-194 TEMPERATURE VARIATIONS IN DEGREES K
ALONG THE TEST TRACK (TEXAS 8-8-73)

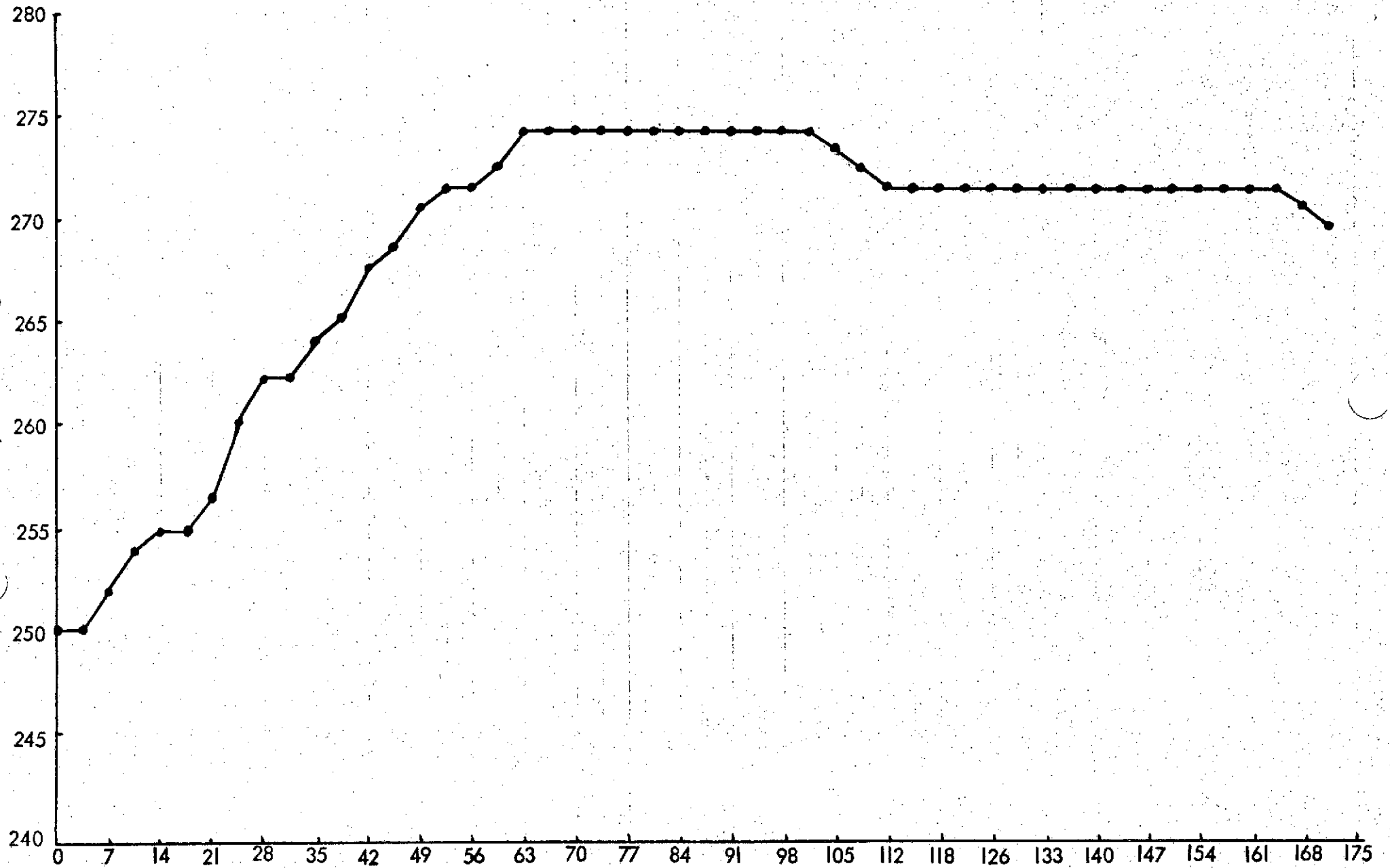



Fig. 11

0 Miles=Lat. 33.861 Long. 101.686
171 Miles=Lat. 31.817 Long. 99.033

VARIATION OF THE AVERAGE SOIL MOISTURE (0-1 INCH LAYER)
BY % OF WEIGHT ALONG THE TEST TRACK (TEXAS 8-8-73)

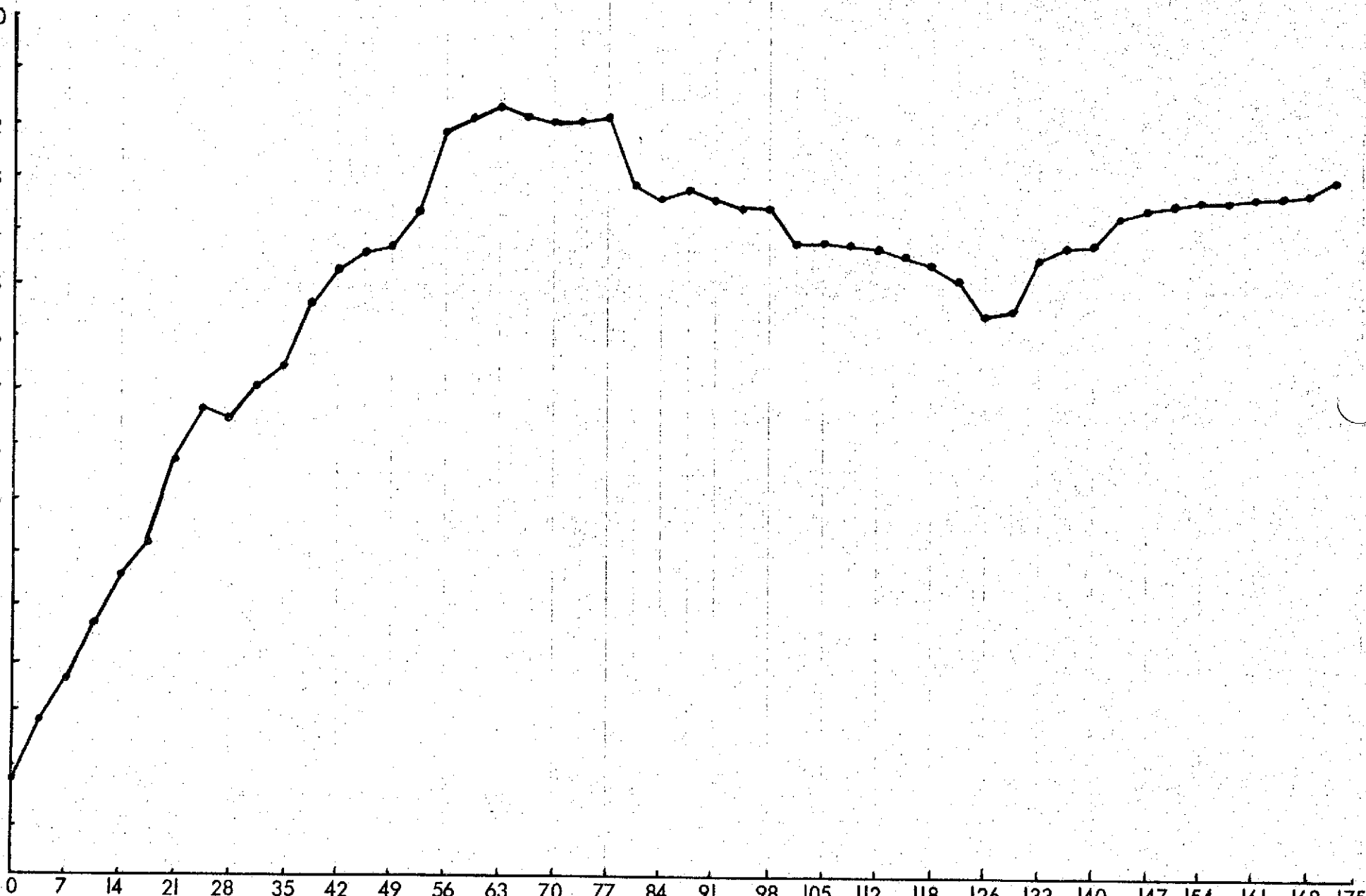



Figure 12

0 Miles=Lat. 33.861 Long. 101.686
171 Miles=Lat. 31. 817 Long. 99.033